U.S. Army Research, Development and Engineering Command

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Expeditionary Lighting Systems for Military Shelters

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Report Documentation Page

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Agenda

- Purpose
- Evaluation Criteria/Measurements of Lighting
- Current MIL SPEC Fluorescent Lighting System
- Past Lighting Efforts
- New Technology Overview
- Current Lighting Projects
  - Technologies of Interest
  - Preliminary Results
- Future Work

Purpose

- Primary lighting systems for military shelters is currently based on fluorescent lighting.

- Many new lighting technologies exist that can benefit the Army in a multitude of ways including energy efficiency, durability, and production of “higher quality” light.

- STEFD has set out to investigate if these new lighting technologies are applicable for use in military shelters by meeting Warfighter needs, saving power, and maintaining a reasonable initial cost.

Evaluation Criteria

Light Color Temperature

- Measure of chromaticity versus an ideal black-body radiator
- Temperature in Kelvin (K) of a heated black-body radiator to match the color of the light source (CCT)

Cool: +5000 K
Warm: -2500 K
Daylight: ~6000 K

Luminous Efficacy

- Measure of luminous flux per watt
- Luminous flux is considered the amount of useful light measured in lumens (lm)
- Could be considered an efficiency rating, it is a good means of comparison between technologies

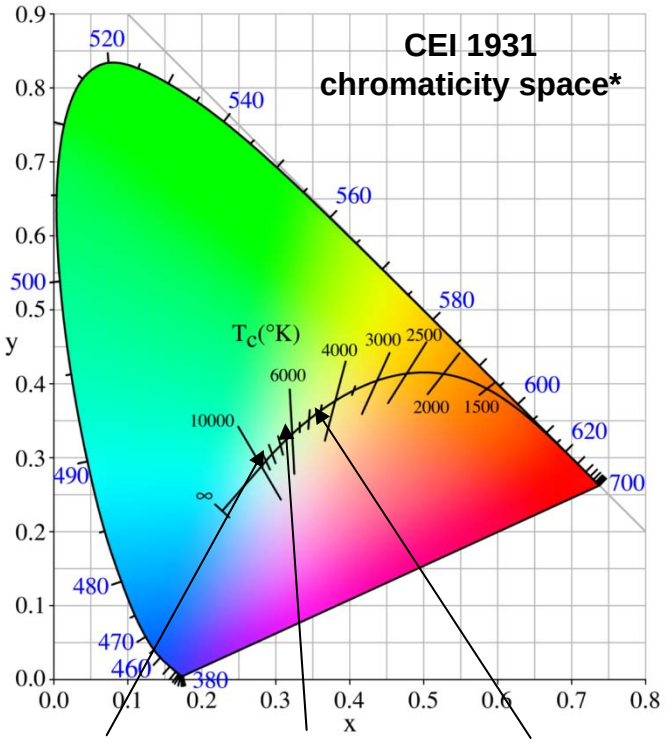
Luminous efficacy is the measure of useful light per watt

Illuminance

- Total luminous flux incident on a surface per unit area
- Measure of the intensity of the incident light, often incorrectly called brightness

Illuminance is measured in lux (lx) or (lm/m^2)

Fluorescent light has 6 target Correlated Color Temperatures (CCT), 3 with names…



Cool Light Daylight Warm Light

White Light

*CEI is the International Commission on Illumination

Base of Comparison for New Technologies

•MIL-PRF-44259D for Lightweight Portable Fluorescent Lights

- Power cord/socket compatibility
- Voltage:120 VAC 50-60 Hz
- Illuminance value of 1506.95 lux at 18” distance
- Weight & size

MIL SPEC Fluorescent Lights

- Current Standard
- Electronic Ballast
- Illumination: 1598.44 lux
- Length: 32.8 inches
- Weight: 4.5 lbs each
- Current draw: < 0.7 Amps

Challenges:

- Fragile compared to solid state lighting technologies
- Light emitter is heavier and bigger compared to new lighting technologies
- Special disposal requirements compared to new lighting technologies

Past Lighting Efforts

Accomplishments

✓Matured multiple lighting technologies to TRL 6

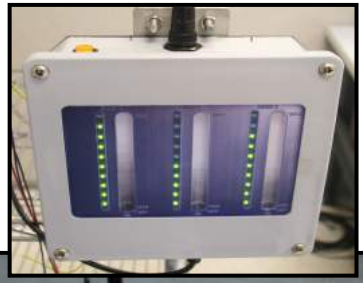
- SBIR and Congressional Funding
  - 2 LED SBIR Projects
  - 1 Electroluminescence Lighting Congressional Effort

✓Completed user evaluations

Crosslink

POC SOSIL

Techshot SLS



Lighting Technologies Under Evaluation

Electroluminescence (EL)

Light Emitting Diodes (LED)

User Feedback:

<u>All lighting systems were considered acceptable</u>

Preferences:

- LEDs brighter
- EL has best light signature
- LEDs best for getting work done
- EL better for light adaptation
- Fluorescent brighter compared to EL, but create more glare

•No clear-cut favorite between LED and EL, each technology excelled for different reasons

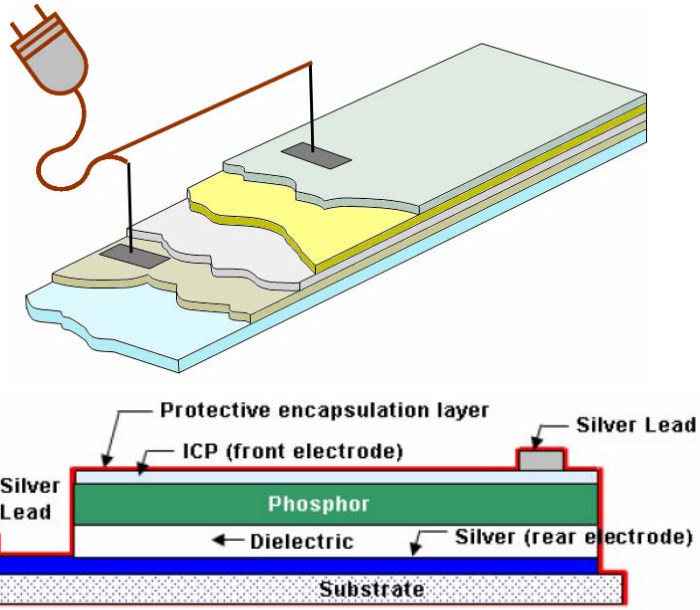
A minimum of <u>1506.95</u> lux per light is required by MIL-PRF-44259D when measured at 18" from source

Results:

Task	LED	Fluorescent	EL
Color Identification /Disorientation	Pass	Pass	Pass
Computer Display	Pass	Pass	Pass
Reading	Pass	Pass	Pass
Writing	Pass	Pass	Pass

Flexible, Electroluminescent (EL) Lighting Surfaces

- Provide general illumination for shelters
- Decreases deployment time, weight, and cube
- Polymer-based lighting surfaces are flexible, durable and safe
- Can be printed on multiple substrates (including fabric)
- Puncture of EL lamp does not cause failure
- Integration in shelter fabric
- High current draw required, and therefore more power used
- Low lux rating currently not near level of fluorescents



How it works

- In the presence of alternating current, the light-emitting layer acts as a capacitor. As the polarity of the current changes, the capacitor will continually charge up and discharge. An alternating electric field is created across the light-emitting layer, energizing the phosphor particles to emit light via electroluminescence.
- The intensity of the light depends on the amount of energy stored in the capacitor and then transferred to the phosphor particles.

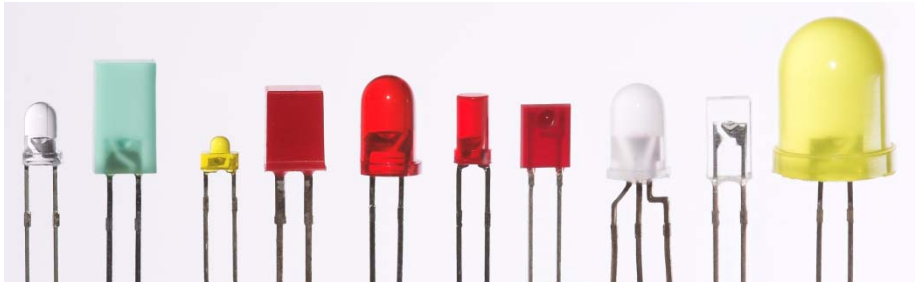
Shelter Illumination with Light Emitting Diodes (LED's)

Advantages:

- Produces necessary illumination using less power*
- Better quality light (visual spectrum white light)
- Ability to be permanently attached to shelter to decrease setup time
- Can produce multiple colors without filters
- Compact, lightweight
- Optimized for even, non-dazzling light, no flicker
- All light is directed to the floor (no dispersed light)
- Longer life than fluorescent light

Disadvantages:

- Heat must be removed by heat sink to prevent failure
- Requires more precise current, high current results in lower efficiency
- High initial cost, currently
- Light dims at end of lifetime



* At low current and temperature

Joint NSRDEC/PM-FSS Evaluation

Objective:

Assess if LED and EL lighting technologies are ready for technology transfer.

Evaluate:

- Form, Fit, and Function
- Cost, including life cycle costs
- Reparability, Maintainability, Safety
- Perform Energy Savings Evaluation as part of the Net Zero Plus Joint Capability Technology Demonstration

Assess:

- Continue to analyze results from light measurements
- Utilize user evaluation data
- Power savings vs. cost vs. light quality

This project seeks to feed the development of next generation lighting technologies. Investigation of new lighting technologies is continuously ongoing.

Current Lighting Project

Three lighting technologies over five lighting systems are being evaluated and compared.

Current Army Lighting System:

- **Technology:** Fluorescent
  - o Jameson

New Lighting Technologies:

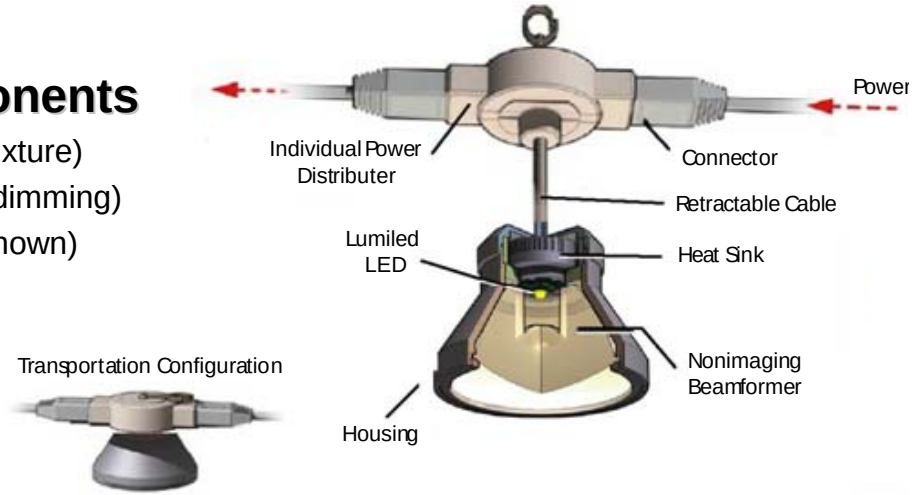
- **Technology:** Light Emitting Diode (LED)
  - o Physical Optics Corp [SBIR]
  - o Techshot [SBIR] [Congressional Effort
  - o Jameson LED System
- **Technology:** Electroluminescence (EL)
  - o Crosslink [Congressional Effort]

SOSIL Concept Lighting System

Phase I SOSIL Prototype Application in Army Tent

SOSIL Components

- Luminaire (lamp fixture)
- Remote Control (dimming)
- Power Box (not shown)
- Mounting system

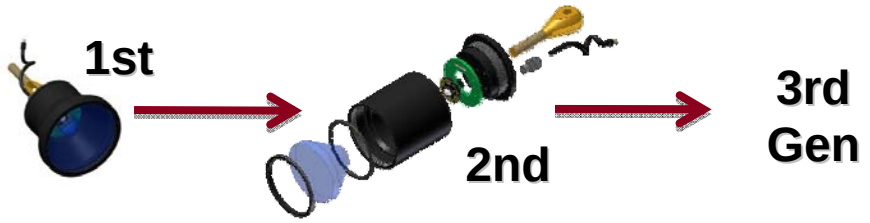


SOSIL Application

- Designed as a drop in replacement for existing fluorescent fixtures.
- Our early demonstration unit is shown on the left.
- Future developments include:
  - Optimized fixture mounting methods that allow the fixtures to be left in place in the tent.
  - Reduce cost
  - Development of “tent kit” for use with Phase II/III SOSIL fixtures.
  - GSA and National Stock Number Assignment

3rd Generation Development

- Currently pursuing CPP program funding.
- Major Goals
- ✓ Reduce fabrication costs
- ✓ Prepare device for mass production in short term.



Techshot LED Shelter Lighting System (SLS)

techshot

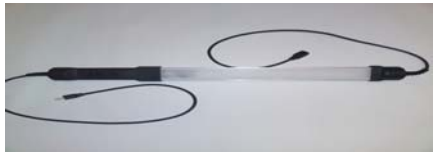


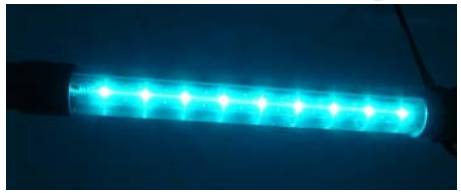




- Solid state LED lighting
- Est. 50,000 hour life, maintenance free
- Three modes: White, Off, Blackout Blue
- Approx. 30% more efficient than Jameson Fluorescents
- Light module designed to fill volume while producing high lux measurements at and along workspace surface
- Can daisy-chain up to 20 light strands from a single 110VAC source
- Designed to hang, drop or drape in most shelters/systems
- Designed for harsh environment, conforms to MIL-STD 810 for High and Low Temperatures with no performance loss
- Robust cables and cast housing, can withstand daily use and abuse

Jameson LED Shelter Lighting






- Patent pending design utilizes high brightness, high efficiency, 100 lumen/watt LEDs
- Consumes 25% less power than current fluorescent shelter lights
- At reduced power draw, light provides the same output and distribution as current fluorescent lights
- Light contains optional power saving mode which reduces output and power consumption by 50%
- Push button switch allows for blackout mode (converts to blue light at 10% of full power)
- Weight and cube is same as current fluorescent lights
- LEDs are rated for 50,000 hours, even under extreme operating conditions
- Color temperature in range of 4100K is similar to current fluorescent lights
- Extremely rugged and durable—no lamp to damage or replace
- Custom designed optical diffuser prevents glare and “eye spots”
- Operates on universal voltage, 90-240 V, 50-60 Hz
- Lights are stringable with pass through power
- Interacts with current fluorescent lights, so can be used to supplement fluorescent lighting
- Light allows for mounting with all approved and customary strapping and hanging methodologies.

Flexible Electroluminescent Lamps for Shelters

Problem

Typical AC power electroluminescent (EL) lamps depend on vacuum-coated and laminated structures that are thick, rigid and limited in their application to very flexible products.

Solution

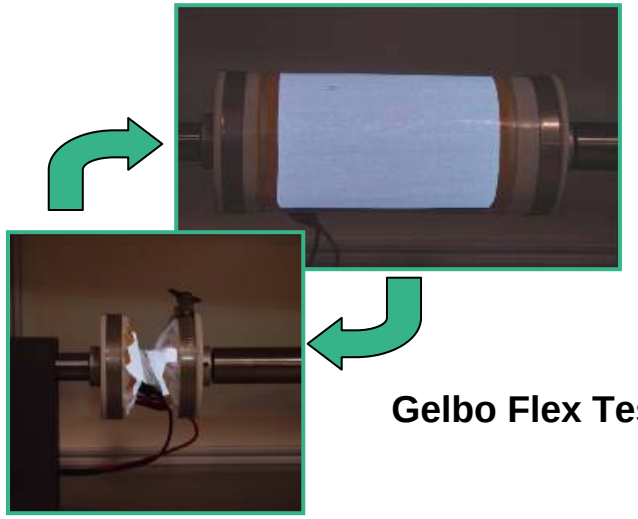
- SuperFlex™ thin, lightweight panels, semi-permanently integrated into the shelter ceilings
- White light, powered by standard AC source
- Manufactured in all-ambient screen printing process by Crosslink, St. Louis, MO
- Extremely durable; can be crushed or punctured without malfunction.
- Shelters can be collapsed and packed quickly, enabling rapid deployment or strike operations.

Available from:

BONDCOTE
PERFORMANCE ENGINEERED COATED FABRICS

Modular Command Post Shelter w/ SuperFlex

Advanced Medical Shelter (ADMS, by Vertigo)



Gelbo Flex Test

Data Description

Lux measurements were taken of each systems 2nd generation prototypes in the summer of 2009 at NSRDEC. Data for both white light and blackout light (blue/green) was collected along with current draw and color temperature.

Points of Reference

- A minimum of 1506.95 lux per light is required by MIL-PRF-44259D when measured at 18 inches from light source
- "Daylight" has a color temperature near 6000 K
- LED efficiency drops as current increases

Measurement	Fluorescent	LED	EL
Lux	1500[1]	900-1500[2]	85-90
Current Draw	2.5 A	1.95-3.0 A[2]	9.2-9.4 A
White Light Temperature	4500 K	4100-6100 K[2]	5400-5600 K

All measurements are at 18 inches below light source
[1] varies with test set up
[2] varies with manufacturer (3 different systems tested)

NSRDEC Early Applied Research Project: Relationship Between Lighting and Cognitive Performance

- **Principle Investigator:** NSRDEC Research Psychologist with support from STEFD Fabric Structures Team and Special Project Team
- **Purpose:** Determine what lighting factors affect soldiers' cognitive performance

Questions?